Claims 1-3, 5, 7-13 and 17-46 are presented for consideration. Claims 1, 17, 27 and 37 independent. Claims 4, 6 and 14-16 have been canceled without prejudice or disclaimer. Claims 1, 5, 7 and 10-13 have been amended to clarify features of the invention, while claims 17-46 have been added to recite additional features of the subject invention. Support for these changes and claims can be found in the original application, as filed. Therefore, no new matter has been added.

Applicants request favorable reconsideration and withdrawal of the objection and rejections set forth in the above-noted Office Action.

Claims 7, 8, 9 and 11-13 were objected to due to minor informalities. The Examiner noted an informality in claim 7, which has been corrected in this response. Accordingly, Applicants request reconsideration and withdrawal of this objection.

Claim 14 was objected to on formal grounds. To expedite allowance of this application, Claim 14 has been canceled without prejudice or disclaimer. Therefore, this objection has become moot and should be withdrawn.

Turning now to the art rejections, claims 1-3 were rejected under 35 U.S.C. § 102 as being anticipated by U.S. Patent No. 5,287,218 to Chen. Claims 15 and 16 were rejected under 35 U.S.C. § 102 as being anticipated by U.S. Patent No. 5,623,365 to Kuba. Claims 1, 3, 4 and 10 were rejected under 35 U.S.C. § 103 as being unpatentable over U.S. Patent No. 5,691,802 to Takahashi in view of the Kuba patent. Claims 1, 3-5, 10 and 13 were rejected under 35 U.S.C. § 103 as being unpatentable over the Takahashi patent in view of the Chen patent. Applicants submit that the cited art, whether taken individually or in combination, does not teach many

a

features of the present invention, as previously recited in claims 1-16. Therefore, these rejections are respectfully traversed.

Nevertheless, Applicants note with appreciation that claims 6-9, 11 and 12 have been indicated as containing allowable subject matter and would be allowed if rewritten in independent form. To expedite allowance of this application, the subject matter of claims 4 and 6 has been substantively incorporated into independent claim 1. The dependencies of claim 5 and 10 have been changed accordingly. Applicants submit, therefore, that independent claim 1 and claims 2, 3, 5 and 7-13, depending therefrom, should be deemed allowable.

In addition, the subject matter of claim 11 has been substantively incorporated into independent claim 11 and is presented as new independent claim 17, the subject matter of claim 12 has been substantively incorporated into independent claim 1 and is presented as new independent claim 27, and the subject matter of claims 4, 5 and 7 has been substantively incorporated into independent claim 1, and is rewritten as new independent claim 37. Applicants submit, therefore, that independent claims 17, 27 and 37, and their respective dependent claims likewise should be deemed allowable.

For the foregoing reasons, Applicants submit that the present invention, as recited in independent claims 1, 17, 27 and 37, is patentably defined over the cited art, whether that art is considered individually or in combination.

Dependent claims 2, 3, 5, 7-13, 18-26, 28-36 and 38-46 also should be deemed allowable, in their own right, for defining other patentable features of the present invention in addition to

a

those recited in their respective independent claims. Further individual consideration of these dependent claims is requested.

Applicants further submit that the instant application is in condition for allowance. Applicants request that the Examiner contact their undersigned representative should any matters be deemed outstanding, precluding allowance of this application. Favorable reconsideration, withdrawal of the objection and rejections set forth in the above-noted Office Action and an early Notice of Allowance are also requested.

Applicants' undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should be directed to our address listed below.

Respectfully submitted,

Attorney for Applicants
Steven E. Warner
Registration No. 33,326

FITZPATRICK, CELLA, HARPER & SCINTO
30 Rockefeller Plaza
New York, New York 10112-3801
Facsimile: (212) 218-2200
SEW/eab

a

Application No. 09/820,710
Attorney Docket No. 00684.003166.

APPENDIX A

IN THE ABSTRACT

[Disclosed is a projection optical system having at least one lens, at least one concave mirror, and at least one diffractive optical element. In one preferred form of the invention, the projection optical system includes a first imaging optical system having the at least one lens and the at least one concave mirror, for imaging an intermediate image of an object, and a second imaging optical system having the at least one lens and at least one diffractive optical element, for projecting the intermediate image onto an image plane.]

-- A projection optical system includes at least one lens, at least one concave mirror, at least one diffractive optical element, a first imaging optical system that includes the at least one lens and the at least one concave mirror, for imaging an intermediate image of an object, a second imaging optical system, having the at least one lens and the at least one diffractive optical element, for projecting the intermediate image onto an image plane, and a field optical system disposed between the first and second imaging optical systems. --

IN THE SPECIFICATION:

Please substitute the paragraph beginning at page 1, line 14, with the following. .

a

-- Recent advancement in semiconductor device manufacturing technology is quite [notably] notable, and micro-processing technology following it also has advanced remarkably. Particularly, in the photo-processing technology, reduction projection exposure apparatuses having a resolution of submicron order and called steppers or scanners, are used widely. For further improvements of resolving power, enlargement of the numerical aperture (NA) of the optical system or shortening of the exposure wavelengths are attempted. --

Please substitute the paragraph beginning at page 1, line 24, and ending on page 2, line 9, with the following.

-- As regards imaging optical systems used in projection exposure apparatuses for printing a semiconductor device pattern such as an IC or LSI on a silicon wafer, for example, a very high resolving power is required. Generally, the resolving power of an imaging optical system is better as the wavelength used is shorter. For this reason, light sources which emit light of shorter wavelengths as much as possible are used. As an example of such a short wavelength light source, excimer lasers are known. [Theses] These excimer lasers use KrF or ArF, for example, as the laser medium. Also, there is an F_2 laser which is expected as a next generation laser of the ArF laser. --

Please substitute the paragraph beginning at page 3, line 8, with the following.

-- Japanese Laid-Open Patent Application, Laid-Open No. 331941/1994 corresponding to U.S. Patent No. 5,623,365 and Japanese Laid-Open Patent Application, Laid-Open No.

a

128590/1995 corresponding to U.S. Patent No. 5,555,497, show an optical arrangement in which, for correction of chromatic aberration, a diffractive optical element is introduced into a projection optical system comprising dioptric systems. In this optical arrangement, a diffractive optical element having a dispersion inverse to that of an ordinary refracting lens is introduced and placed adjacent to a pupil of a dioptric projection optical system, by which axial chromatic aberration is mainly corrected. Also, by means of an aspherical surface effect of the diffractive optical element, aberrations such as spherical aberration and [comma] coma are mainly corrected. --

Please substitute the paragraph beginning at page 4, line 4, with the following.

-- As a method of producing a diffractive optical element having such features very precisely, [a] binary optics [has] have attracted [attentions] attention, for example. This is because a semiconductor process used in the manufacture of an LSI, for example, can be applied to it by approximating a Kinoform shape by a step-like shape, such that even a very small pitch can be produced easily and very precisely. --

Please substitute the paragraph beginning at page 4, line 12, with the following.

-- Japanese Laid-Open Patent Application, Laid-Open No. 78319/1996 corresponding to U.S. Patent No. 5,754,340 shows an optical system having diffractive optical elements, quartz lenses and fluorite lenses, in which at least one diffractive optical element has a positive refractive power, at least one quartz lens has a negative refractive power, and at least one fluorite

a

lens has a positive refractive power. This is intended particularly to reduce a secondary spectrum of chromatic aberration. --

Please substitute the paragraph beginning at page 4, line 22, and ending on page 5, line 16, with the following.

-- Japanese Laid-Open Patent Application, Laid-Open No. 17720/1996 shows an optical system in which a diffractive optical element is introduced into a catoptric system. This optical system includes diffractive optical elements and reflecting members each having a curved reflection surface. The diffractive optical element is provided on the reflection surface. It is stated in this document that the role having been taken by a refracting lens is played by a diffractive optical element, by which a projection optical system of a reduced magnification is accomplished only by the combination of reflection surfaces and diffractive optical elements. Also, it is stated that, since the diffractive optical element has a dispersion corresponding to the bandwidth of light to be used for the projection exposure, in the paraxial region, it is desirable to use the same while keeping its refractive power nearly at zero, that is, at an infinite focal length. Thus, this structure proposes an optical system which can be used in a short wavelength region in which no refracting lens can be used. --

Please substitute the paragraph beginning at page 5, line 17, with the following.

-- Further, many proposals have been made [in] with respect to a combination of a dioptric system and a catoptric system, that is, a catadioptric system. These optical systems are

a

intended to correct chromatic aberration or any other aberrations by a combination of a mirror and a refracting lens, and no diffractive optical element is used. --

Please substitute the paragraph beginning at page 6, line 6, with the following.

-- According to the structure of this document, a flat mirror is disposed adjacent to the intermediate image formed by the first imaging system, to deflect the advancement direction (optical axis) of the light by 90 [deg.] degrees toward the second imaging system. Also, a reflection mirror is provided in the second imaging system so that the wafer surface and the reticle surface are held [in] parallel to each other. This optical system accomplishes scanning exposure by using an abaxial light beam and by scanning the reticle and the wafer in synchronism with each other. --

Please substitute the paragraph beginning at page 6, line 17, and ending on page 7, line 1, with the following.

-- The optical system shown in Japanese Laid-Open Patent Application, Laid-Open No. 331941/1994, mentioned above, in which a diffractive optical element is introduced into a dioptric system, needs a large number of lenses, due to the necessity for aberration correction. Thus, there is a possibility that, due to the influence of thermal aberration or the like, the performance of the projection optical system is degraded. Further, [where] when the wavelength of the exposure light is shortened much more, the influence of the thermal aberration or the like becomes much more notable. --

a

Please substitute the paragraph beginning at page 7, line 24, and ending on page 8, line 8, with the following.

-- As regards the optical system shown in Japanese Laid-Open Patent Application, Laid-Open No. 17720/1996 mentioned above, no specific numeral example is disclosed. Since the aspherical effect of the diffractive optical element is used because, as long as stated there, the power [of] thereof should desirably be held closed to zero, the mirror [owes] <u>owns</u> the refractive power of the optical system. Also, there is no lens used as a refracting lens. For these reasons, a large numerical aperture and a wide exposure range are not attainable with this optical system. --

Please substitute the paragraph beginning at page 8, line 9, and ending on page 9, line 11, with the following.

-- In the optical system shown in Japanese Laid-Open Patent Application, Laid-Open No. 304705/1996 mentioned above, aberration correction is made such that the aberration produced by the first imaging system is cancelled by the second imaging system. For example, in the first imaging system, a concave mirror and a negative lens disposed adjacent <u>to</u> the concave mirror function to produce an "over" image field curvature, while on the other hand, the negative lens produces axial chromatic aberration in the "over" direction. In order to cancel them, the second imaging system is constituted by a refracting lens group. By means of its lenses having a positive power, "under" image field curvature and axial chromatic aberration are produced, by which the aberration correction as a total system is accomplished. However, because of the necessity of correcting the chromatic aberration and the image field curvature concurrently and

a

also correcting any other aberrations, the first imaging system should include many lenses. Particularly, as regards the refracting lenses used in the first imaging system as a reciprocal optical system, unless the number of them are reduced as much as possible, the total thickness of the optical system becomes large and the transmission factor decreases. There arises a large influence of the thermal aberration and the like. --

Please substitute the paragraph beginning at page 9, line 20, with the following.

-- It is accordingly an object of the present invention to provide an improved projection optical system by which a large numerical aperture and a wide exposure area [is] are assured. --

Please substitute the paragraph beginning at page 12, line 1, with the following.

-- (10) A projection optical system according to item (4), further comprising a reflection surface disposed adjacent to an intermediate image formed by said first imaging optical system, and wherein abaxial light from the object as reflected and collected by said concave mirror is deflected by said reflection surface toward said second imaging optical system. --

Please substitute the paragraph beginning at page 12, line 8, with the following.

-- (11) A projection optical system according to any one of items (1) - (10), wherein at least one of the diffractive optical elements of said projection optical system satisfies a relation:

$$3 < MP/\lambda < 50$$

a

where MP is a minimum pitch (micron) of the diffractive optical element, and λ is the exposure wavelength (micron). --

Please substitute the paragraph beginning at page 12, line 16, and ending on page 13, line 2, with the following.

-- (12) A projection optical system according to any one of items (1) - (10), wherein at least one of <u>the</u> diffractive optical elements of said projection optical system satisfies a relation:

$$|Ld/Lg2| < 0.2$$

where Ld is the distance between an aperture stop of said second imaging optical system and said diffractive optical element, and Lg2 is the distance from [an] <u>a</u> paraxial image plane position of an intermediate image formed by said first imaging optical system, corresponding to an object point position of said second imaging optical system, to [an] <u>a</u> re-imaging plane where the intermediate image is re-imaged. --

Please substitute the paragraph beginning at page 13, line 3, with the following.

-- (13) A projection optical system according to any one of items (3) - (12), further comprising a field stop adjacent <u>to</u> an intermediate image to be formed by said first imaging optical system. --

Please substitute the paragraph beginning at page 17, line 26, and ending on page 18, line 4, with the following.

a

-- In designing an optical system, what is to be satisfied first [is] are the correction of curvature of field and chromatic aberration. Since these aberrations largely depend upon the power arrangement of the optical system, they should be considered sufficiently at the initial stage of the designing. --

Please substitute the paragraph beginning at page 19, line 6, with the following.

-- [Where] When an optical system is constituted by a refracting lens (lenses) and a diffractive optical element (elements), the indices F and C are given by equations (3) and (4) below. It is seen from [equation] equations (3) and (4) below that, in order to correct the chromatic aberration C and the field curvature F at once, the optical system inevitably needs a lens (lenses) having a negative refractive power. This is because the diffractive optical element itself does not contribute to the field curvature. --

Please substitute the paragraph beginning at page 20, line 9, with the following.

-- As described above, since the diffractive optical element itself does not produce a field curvature, what [determines] determines the field curvature [is] are the mirror and the refracting lens. Further, since the mirror does not contribute to correction of chromatic aberration, the refracting lens and the diffractive optical element function to correct the same. Thus, when a projection optical system is formed by use of three kinds of elements of refracting lens, mirror and diffractive optical element, if a lens (lenses) having a negative refractive power is prevented from being used in the optical system, the results are as follows. --

a

Please substitute the paragraph beginning at page 23, line 1, with the following.

-- However, because of reflection of light at the mirror surface, there arise several problems. Particularly, [where] <u>when</u> a mirror is used in a single-imaging optical system, it is necessary that the light incident on the mirror and the light emitted from it are separated from each other when [image] <u>imaged</u> upon an image plane. To this end, a beam splitter should be used, for example. Alternatively, an optical system should be arranged to produce a void in its pull. --

Please substitute the paragraph beginning at page 23, line 10, with the following.

-- Further, generally, if in a multiple-imaging optical system a mirror is disposed in a final imaging optical system, it is difficult to keep a sufficient back focus, and therefore, the optical arrangement for separating the light incident on the mirror and the light emitted [from it] from each other becomes complicated. Here, the final imaging optical system is one of the imaging systems which is closest to the second object (wafer) in Figure 1. Additionally, if a larger numerical aperture is desired, the arrangement becomes more strict and, on the other hand, the size of the mirror becomes larger. In consideration of them, in a multiple-imaging optical system, a mirror should desirably be placed on an imaging optical system other than the final imaging optical system. --

Please substitute the paragraph beginning at page 24, line 9, with the following.

a

-- Thus, although a mirror has a feature that it does not produce chromatic aberration as a characteristic thereof and it has a relation between the power and the Petzval sum of a sign inverse to that of an ordinary refracting lens, a diffractive optical element has features that [it] the dispersion is inverse to an ordinary refracting lens whereas the Petzval sum is zero. --

Please substitute the paragraph beginning at page 24, line 21, and ending on page 25, line 17, with the following.

-- (a) [Where] <u>When</u> the optical elements constituting an optical system are all refracting lenses, in order that both the field curvature and the chromatic aberration are corrected at once in an optical system having a large numerical aperture and a wide exposure range, it needs use of a large number of refracting lenses. One reason for this is that the glass materials usable in the short wavelength region are very limited, and currently available glass materials usable with the ArF wavelength are quartz and fluorite only, while, as regards the F_2 wavelength, only fluorite has a high transmission factor. Particularly, in relation to the F_2 wavelength, as long as the fluorite is <u>the</u> only [the] glass material usable therewith, there remains chromatic aberration unless the F_2 laser is band-narrowed sufficiently to reduce the chromatic aberration satisfactorily. Further, for correction of field curvature, a refracting lens having a positive refractive power and a refracting lens having a negative refractive power should be used effectively. This inevitably results in an increase [of] <u>in</u> the number of lens elements in the optical system having a large numerical aperture and a wide exposure range. --

a

Please substitute the paragraph beginning at page 25, line 18, and ending on page 26, line 3, with the following.

-- (b) [Where] When an optical system is constituted by a refracting lens (lenses) and a diffractive optical element (elements), while the diffractive optical element is effective as a freedom for correction of chromatic aberration, it does not directly concern the correction of field curvature. Thus, in order that both the field curvature and chromatic aberration are corrected at once in an optical system having a large numerical aperture and a wide exposure range, it inevitably needs use of an increased number of refracting lenses having a negative refractive power. This is an obstruction for simplification of the structure. --

Please substitute the paragraph beginning at page 26, line 4, with the following.

-- (c) [Where] When an optical system is constituted by a mirror (mirrors) and a refracting lens (lenses), while the mirror is effective as a freedom for correction of field curvature, it does not directly concern the correction of chromatic aberration. Thus, in order that both the field curvature and chromatic aberration are corrected at once in an optical system having a large numerical aperture and a wide exposure range, similarly, it needs use of an increased number of refracting lenses having positive and negative refractive power. --

Please substitute the paragraph beginning at page 26, line 26, and ending on page 27, line 5, with the following.

a

-- Thus, use of <u>the</u> three elements of refracting lens, mirror and diffractive optical element, positively as described above, enables an optical system having a large numerical aperture and a wide exposure range, in which field curvature and chromatic aberration are corrected at once with a simple structure. --

Please substitute the paragraph beginning at page 28, line 22, and ending on page 29, line 4, with the following.

-- Equation (9) above defines a condition related to the pitch of the diffractive optical element. If the upper limit thereof is exceeded, the pitch of the diffractive optical element becomes too large, and the effect thereof does not function well. Therefore, sufficient correction of chromatic aberration and simplicity in structure are not attainable. If the lower limit is exceeded, the pitch of the <u>element</u> becomes too small, to the contrary, such that the manufacture thereof becomes difficult. --

Please substitute the paragraph beginning at page 29, line 5, with the following.

-- Further, preferably, at least one of <u>the</u> diffractive optical elements used in the projection optical system should be disposed at a position which satisfies the following condition:

$$|Ld/LG2| < 0.2 \qquad \ldots (10)$$

where Ld is the distance between an aperture stop of the second imaging optical system and the diffractive optical element, and LG2 is the distance from the paraxial image plane position of the

a

first imaging optical system (corresponding to the axial object point position of the second imaging optical system G2) to the re-imaging plane where the intermediate image is re-imaged. --

Please substitute the paragraph beginning at page 30, line 13, with the following.

-- In Figure 3, for example, Lo corresponds to the following distance:

Lo = (distance from object surface 101 to first mirror M1) + (distance from first mirror M1 to second mirror M2) + (distance from second mirror M2 to image plane 102). --

Please substitute the paragraph beginning at page 30, line 19, and ending on page 31, line 12, with the following.

-- Equation (11) above determines an appropriate value for the effective diameter of the second imaging optical system and, also, it defines the magnification of the second imaging optical system G2 to assure a predetermined magnification throughout the optical system as a whole or [to] simplifies the structure of the first imaging optical system G1. If the lower limit of the same is exceeded, the effective diameter of the second imaging optical system G2 increases excessively and, additionally, the height of the intermediate image (object height in the second imaging optical system G2) becomes small. As a result, it becomes difficult to direct light from the first imaging optical system G1 to the second imaging optical system G2. If the upper limit is exceeded, the refractive power of the second imaging optical system G2 becomes large, so that

a

the aberration correction becomes difficult to accomplish. Also, the height of the intermediate image (object height in the second imaging optical system G2) increases excessively. This is undesirable. --

Please substitute the paragraph beginning at page 31, line 13, with the following.

-- Equation (12) above defines the position of the first mirror M1 with respect to the total axial optical length of the optical system. If the lower limit is exceeded, the refractive power of the first imaging optical system increases, and aberration correction becomes difficult. If the upper limit is exceeded, the effective diameter of the first mirror M1 increases excessively, such that the refractive power of the second imaging optical system G2 increases. As a result, well-balanced aberration correction in the whole system [can not] <u>cannot</u> be attained. --

Please substitute the paragraph beginning at page 31, line 24, with the following.

-- A field stop may be provided adjacent <u>to</u> an intermediate image formed by the first imaging optical system G1, by which the exposure range can be restricted. --

Please substitute the paragraph beginning at page 32, line 1, with the following.

-- This embodiment is particularly effective for structuring a projection optical system having a large numerical aperture and a wide exposure range and to be used with a light source of <u>a</u> short wavelength (exposure wavelength) of 200 nm or shorter, since, in the short wavelength region, such as <u>that of an</u> ArF excimer laser or <u>an</u> F_2 excimer laser, usable glass materials are

a

limited such that correction of chromatic aberration is difficult to accomplish only with the use of ordinary refracting lenses. --

Please substitute the paragraph beginning at page 32, line 11, with the following.

-- As regards lenses and diffractive optical elements, for the short wavelength region of 200 nm or shorter as that of ArF or F_2, a material having a high light transmissivity such as composite quartz (or fluorine doped quartz) or fluorite, for example, may be used. Further, these optical elements may desirably be disposed in an ambience of inactive gas such as N_2 or He. --

Please substitute the paragraph beginning at page 32, line 19, with the following.

-- Several specific examples of the present invention will be described below. In each of these examples, the optical system is structured as a projection optical system to be used in a projection exposure apparatus of a step-and-repeat type or step-and-scan type. In ordinary lithographic processes, a wafer is exposed to a device pattern by use of this exposure apparatus, and a development process and an etching process are then made to the exposed wafer. --

Please substitute the paragraph beginning at page 33, line 2, with the following.

-- Figure 3 shows the lens structure according to Example 1 of the present invention. In this example, the optical system includes at least one mirror, at least one lens and at least one diffractive optical element. Those optical [element] elements having a focal length in the optical system are all designed to have a positive refractive power. Denoted at 103 is an optical axis of

a

this optical system. The optical system comprises a double-imaging optical system which includes at least a first imaging optical system G1 for forming an intermediate image of the first object 101 and a second imaging optical system G2 for imaging the intermediate image upon the second object 102. The first imaging optical system G1 comprises at least one mirror and at least one refracting lens, while the second imaging optical system G2 comprises at least one refracting lens and at least one diffractive optical element. --

Please substitute the paragraph beginning at page 34, line 23, and ending on page 35, line 6, with the following.

-- In this example, the image side numerical aperture was NA = 0.6, and the reduction magnification was 1:4. The object-to-image distance (from the surface of the first object to the surface of the second object) was L - about 1160 mm. Aberrations were corrected with respect to the reference wavelength of 157 nm, and within [a] <u>an</u> image height range of about 11.25 - 16.25 mm. Upon an image plane, an arcuate exposure region of a size of at least about 26 mm in the lengthwise direction and about 4 mm in the widthwise direction, was assured. --

Please substitute the paragraph beginning at page 35, line 20, and ending on page 36, line 2, with the following.

-- The group L2, including two mirrors, comprises, in an order form passage of light from the refracting lens group L1, an aspherical mirror having a concave surface facing [to] the object side, and an aspherical mirror having a concave surface facing [to] the image side. These mirrors

a

function to produce a field curvature in the "over" direction, by which an image field curvature to be produced in the second imaging optical system G2 in the "under" direction can be cancelled. --

Please substitute the paragraph beginning at page 36, line 3, with the following.

-- Further, the groups L1 and L2 cooperate to form an intermediate image at a position adjacent to the first mirror M1. --

Please substitute the paragraph beginning at page 36, line 13, with the following.

-- The second imaging optical system G2 comprises, in an order from the object side, a diffractive optical element having a positive refractive power, an aperture stop, a diffractive optical element having a positive refractive power, two aspherical positive lenses of biconvex shape, and an aspherical lens having a convex shape facing [to] the object side. --

Please substitute the paragraph beginning at page 36, line 21, and ending on page 37, line 9, with the following.

-- Both of the two diffractive optical elements have a minimum pitch of about 2 microns. Namely, [where a] when binary optics [is] are used to approximate this diffractive optical element by a step-like shape and if an eight-level stepped structure is to be provided, the width of each step is about 0.25 micron. This can be well produced by using a semiconductor exposure apparatus having a light source of KrF, for example. These diffractive optical elements are used

a

to mainly correct a large "under" axial chromatic aberration to be produced by the second imaging optical system G2, and also to correct the balance of chromatic aberration of the total system magnification. Further, through the aspherical surface effect, they contribute mainly to the correction of spherical aberration and [comma] coma. --

Please substitute the paragraph beginning at page 37, line 24, and ending on page 38, line 6, with the following.

-- In this example, the conical constant k is taken as zero. However, the design may be made while taking the conical constant as a variable. Further, in this example, only fluorite was used as a glass material for a wavelength of 157 nm[, if]. If any other glass material such as fluorine doped quartz, for example, is available, it may be used. [Where] When the light source comprises a KrF excimer laser of an ArF excimer laser, fluorite and quartz may be used in combination. Of course, one of them may be used. --

Please substitute the paragraph beginning at page 38, line 7, with the following.

-- While, in this example, [a] an F_2 excimer laser having an emission wavelength of 157 nm was used as an exposure light source, a KrF excimer laser or an ArF excimer laser may be used. The invention is particularly effective [where] when it is applied to an optical system in a case wherein the wavelength is shorter and usable optical materials are limited, and wherein the transmission factor becomes low so that the number of structural elements of the optical system

a

should be reduced. Therefore, the invention is very effective [to] in an optical system to be used with a wavelength not greater than 250 nm. --

Please substitute the paragraph beginning at page 39, line 17, with the following.

-- [Where] When a diffractive optical element is produced on the basis of [a] binary optics, the number of steps (levels) approximating a Kinoform may be other than eight. --

Please substitute the paragraph beginning at page 41, line 25, and ending on page 42, line 24, with the following.

-- The refracting lens group L1 comprises, in an order from the object side, an aspherical positive lens of meniscus shape having a concave surface facing [to] the object side, and an aspherical positive lens of approximately flat-convex shape having a convex surface facing [to] the image plane side. This lens group L1 mainly serves to keep a well corrected balance of the distortion and the telecentricity, and also to direct an abaxial light flux from the first object to the first mirror M1. The first mirror M1 is a concave mirror having a concave surface facing [to] the object side, and it has a positive refractive power. It functions to produce a field curvature in the positive direction, to cancel a negative field curvature to be produced by the second imaging optical system. The second mirror M2 is a concave mirror having a concave surface facing to the image side. It operates to direct the abaxial light flux from the first object 101 to the outside of the first mirror M1. The intermediate image being imaged by the first imaging optical system is formed adjacent to the outside of the effective diameter of the first mirror M1 (in this example,

a

the light reflected by the second mirror M2 in a direction toward the second imaging optical system G2 is defined at a portion closer to the mirror M2 from the outside of the effective diameter of the first mirror M1).

Please substitute the paragraph beginning at page 43, line 3, with the following.

-- In this example, a single aspherical lens of biconvex shape is disposed as the field lens group F, at a position adjacent <u>to</u> the intermediate image. --

Please substitute the paragraph beginning at page 43, line 6, with the following.

-- As shown in Figure 15, the provisions of a field lens group F adjacent <u>to</u> the intermediate image is very effective to separate the light from the second mirror M2 with respect to the first mirror M1 and a refracting lens group R, without excessively increasing the mirror refractive power in the group L2 including [tow] <u>two</u> mirrors. Preferably, this field lens group F may have a positive refractive power, so that it may function to refract the light from the first imaging optical system G1 toward the second imaging optical system G2 to thereby avoid enlargement in size of the effective diameter of the second imaging optical system G2. Thus, it assures a smaller effective diameter of the second imaging optical system. Further, since it is disposed adjacent <u>to</u> the intermediate image, it functions well for correction of abaxial aberration such as distortion aberration, for example. --

Please substitute the paragraph beginning at page 44, line 18, with the following.

a

-- Each of the two diffractive optical elements has a minimum pitch of about 2.5 microns. Thus, [where a] <u>when</u> binary optics [is] <u>are</u> used to produce this diffractive optical element and if an eight-level structure per pitch is to be formed, the smallest linewidth required for the smallest pitch of this diffractive optical element is about 0.31 micron. --

Please substitute the paragraph beginning at page 47, line 12, with the following.

-- The refracting lens group R which is a reciprocal optical system comprises an aspherical negative lens of meniscus shape, having a concave surface facing [to] the object side. With this negative lens, mainly the field curvature and axial chromatic aberration to be produced by the second imaging optical system G2 are corrected with a good balance and, additionally, spherical aberration and [comma] <u>coma</u>, for example, are also corrected. --

Please substitute the paragraph beginning at page 47, line 21, and ending on page 48, line 8, with the following.

-- The first mirror M1 is a concave mirror having a concave surface facing to the object side, and it has a positive refractive power. It functions to produce a field curvature in the positive direction, to cancel a negative field curvature to be produced by the positive refracting lens of the second imaging optical system. The second mirror M2 is a concave mirror having a concave surface facing [to] the image side. It operates to direct the abaxial light flux from the first object 101 to the outside of the first mirror M1. The intermediate image is formed adjacent <u>to</u> the outside of the effective diameter of the first mirror M1. Further, a single aspherical lens of

a

biconvex shape is disposed as the field lens group F, at a position adjacent to the intermediate image. --

Please substitute the paragraph beginning at page 48, line 22, and ending on page 49, line 1, with the following.

-- Each of the two diffractive optical elements has a minimum pitch of about 2.0 microns. Thus, [where a] when binary optics [is] are used to produce this diffractive optical element and if an eight-level structure per pitch is to be formed, the smallest linewidth required for the smallest pitch of this diffractive optical element is about 0.25 micron. --

Please substitute the paragraph beginning at page 49, line 6, with the following.

-- Although in this example the refracting lens group R is disposed adjacent to the first mirror M1, it may be disposed adjacent to the second mirror M2. Namely, as shown in Figure 6A, the lens group may be disposed at the position for passing the reflection light from the first mirror M1 and the reflection light from the second mirror M2. Figures 6B, 6C and 6D show modified examples. In Figure 6B, it is disposed at a position for passing the light from the refracting lens group L1, the reflection light from the first mirror M1 and the reflection light from the second mirror. In Figures 6C and 6D, a portion of the refracting lens is formed with a reflection mirror. In these cases, the refracting lens group L1 and the second mirror M2 may be provided by one refracting lens. --

a

Please substitute the paragraph beginning at page 50, line 16, and ending on page 51, line 5, with the following.

-- Figure 7 is a schematic view of a projection optical system according to Example 4 of the present invention. The first imaging optical system G1 comprises, in an order from the object side, at least a group L1 having a refracting lens, and a group L2 having at least one concave mirror 501. Light from the first object 101 is imaged by the first imaging optical system G1, whereby an intermediate image is formed. Here, there is a reflection surface 502 disposed adjacent <u>to</u> the intermediate image formed by the first imaging optical system G1, for deflecting the light, by which the abaxial light flux from the first object 101 and the light from the concave mirror 501 are separated from each other. The light is then directed to a second imaging optical system G2 which is constituted by a refracting lens and a diffractive optical element. --

Please substitute the paragraph beginning at page 52, line 9, with the following.

-- Denoted in Figure 7 at 502 is a reflection surface which, in this example, serves to deflect the optical axis 503 by 90 [deg] <u>degrees</u>. The intermediate image of the first imaging optical system G1 is formed adjacent <u>to</u> the reflection surface 502. --

Please substitute the paragraph beginning at page 52, line 24, and ending on page 53, line 5, with the following.

-- The diffractive optical elements have minimum pitches of about 2.25 microns and 2.20 microns, in the order being far away from the image plane. Thus, [where a] <u>when</u> binary optics

[is] are used to produce this diffractive optical element and if an eight-level structure per pitch is to be formed, the smallest linewidths required for the smallest pitch of this diffractive optical element are about 0.28 micron and 0.27 micron, respectively. --

Please substitute the paragraph beginning at page 53, line 6, with the following.

-- Although in this embodiment a reciprocal optical system R5 is disposed inside the group L2, it may be omitted as shown in Figure 8. Further, a flat mirror may be disposed in the second imaging optical system, and, [in] on that occasion, the object plane 101 and the image plane 102 may be disposed [in] parallel to each other. --

Please substitute the paragraph beginning at page 54, line 19, and ending on page 55, line 9, with the following.

-- The refracting lens group L1 comprises, in an order from the object side, an aspherical positive lens of biconvex shape. The group L2 including a mirror comprises a first mirror M1 and a second mirror M2. Each of the first and second mirrors is a concave mirror having a concave surface facing [to] the object side. The second imaging optical system comprises, in an order from the object side, an aspherical positive lens of meniscus shape having a convex surface facing [to] the object side (this lens system may be considered [as] to be a field optical system, and it may be or may not be included in the second imaging system), a diffractive optical element D1 having a positive refractive power, an aperture stop, a diffractive optical element D2 having a

a

positive refractive power, two aspherical positive lenses of biconvex shape, and an aspherical positive lens having a convex surface facing [to] the object side. --

Please substitute the paragraph beginning at page 55, line 10, with the following.

-- Each of the two diffractive optical elements has a minimum pitch of about 2.0 microns. Thus, [where a] <u>when</u> binary optics [is] <u>are</u> used to produce this diffractive optical element and if an eight-level structure per pitch is to be formed, the smallest linewidth required for the smallest pitch of this diffractive optical element is about 0.25 micron. --

Please substitute the paragraph beginning at page 56, line 15, with the following.

-- Further, although [a] <u>an</u> F_2 excimer laser having an emission wavelength of 157 nm was used as an exposure light source, <u>an</u> ArF excimer laser, for example, may be used. The invention is particularly effective [where] <u>when</u> the wavelength is short and usable optical materials are limited, more specifically, the wavelength is not greater than 200 nm. --

Please substitute the paragraph beginning at page 56, line 22, and ending on page 57, line 1, with the following.

-- Further, although only fluorite was used as a glass material, if any other glass material becomes available with reference to F_2 excimer lasers, it may be used. In relation to <u>the</u> use of ArF excimer lasers, fluorite and quartz may be used in combination with [a] good results of aberration correction. Of course, one of them may be used. --

a

Please substitute the paragraph beginning at page 57, line 6, with the following.

-- Further, although two diffractive optical elements are used, the present invention is not limited to this. Only one diffractive optical element may be used or, alternatively, many diffractive optical elements may be used. [Where] When plural diffractive optical elements are used, those diffractive optical elements having the same phase function may be used. --

Please substitute the paragraph beginning at page 58, line 11, with the following.

-- where X is the amount of shift in the optical axis direction from the lens vertex, H is the distance from the optical axis, r_i is the curvature radius, k is the conical constant, and A, B, ..., G are aspherical surface coefficients. --

IN THE CLAIMS

1. (Amended) A projection optical system, comprising:

at least one lens;

at least one concave mirror; [and]

at least one diffractive optical element;

a first imaging optical system, having said at least one lens and said at least one concave mirror, for imaging an intermediate image of an object;

a second imaging optical system, having said at least one lens and at least one diffractive optical element, for projectiong the intermediate image onto an image plane; and

a field optical system disposed between said first and second imaging optical systems.

5. (Amended) A projection optical system according to Claim [4] 1, wherein said first and second imaging optical systems are disposed along a common straight optical axis, and wherein biaxial light from the object as reflected and collected by said concave mirror is caused by said mirror to pass through an outside portion of an effective diameter of said concave mirror, toward the image plane side.

7. (Amended) A projection optical system according to Claim 5, wherein said first imaging optical system includes at least a lens having a positive refractive power, [said] a reflection mirror and said concave mirror, which are disposed in the order mentioned above, from the object side.

10. (Amended) A projection optical system according to Claim [4] 1, further comprising a reflection surface disposed adjacent to an intermediate image formed by said first imaging optical system, and wherein abaxial light from the object as reflected and collected by said concave mirror is deflected by said reflection surface toward said second imaging optical system.

11. (Amended) A projection optical system according to any one of Claims [1 - 10] 1-3, 5 and 7-10, wherein said at least one of diffractive optical elements of said projection optical system satisfies a relation:

$$3 < MP/\lambda < 50$$

where MP is a minimum pitch (micron) of the diffractive optical element, and λ is the exposure wavelength (micron).

12. (Amended) A projection optical system according to any one of Claims [1 - 10] 1-3, 5, and 7-10, wherein at least one of diffractive optical elements of said projection optical system satisfies a relation:

$$|Ld/Lg2| < 0.2$$

where Ld is the distance between an aperture stop of said second imaging optical system and said diffractive optical element, and Lg2 is the distance from [an] a paraxial image plane position of an intermediate image formed by said first imaging optical system, corresponding to an object point position of said second imaging optical system, to [an] a re-imaging plane where the intermediate image is re-imaged.

13. (Amended) A projection optical system according to any one of Claims [3 - 10] 3, 5 and 7-10, further comprising a field stop adjacent to an intermediate image to be formed by said first imaging optical system.